NPS MDP Study
Outbrief Schedule, 1 JUN 2005

0800-0815 Introductions

0815-0915 Background/Results

0930-1015 Cargo Inspection System (Land)

1030-1130 Cargo Inspection System (Sea)

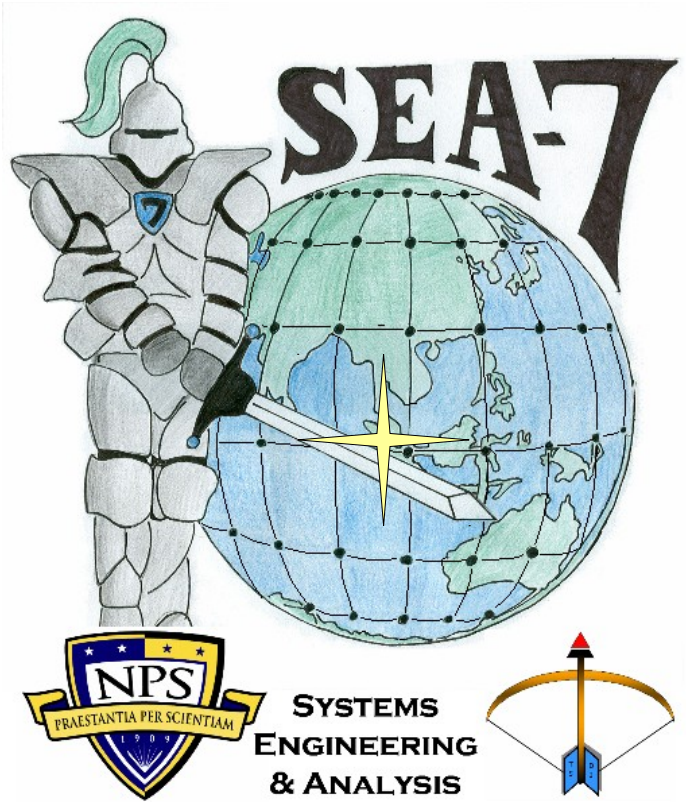
1130-1230 **LUNCH**

1230-1330 Sensor System

1345-1445 C3I System

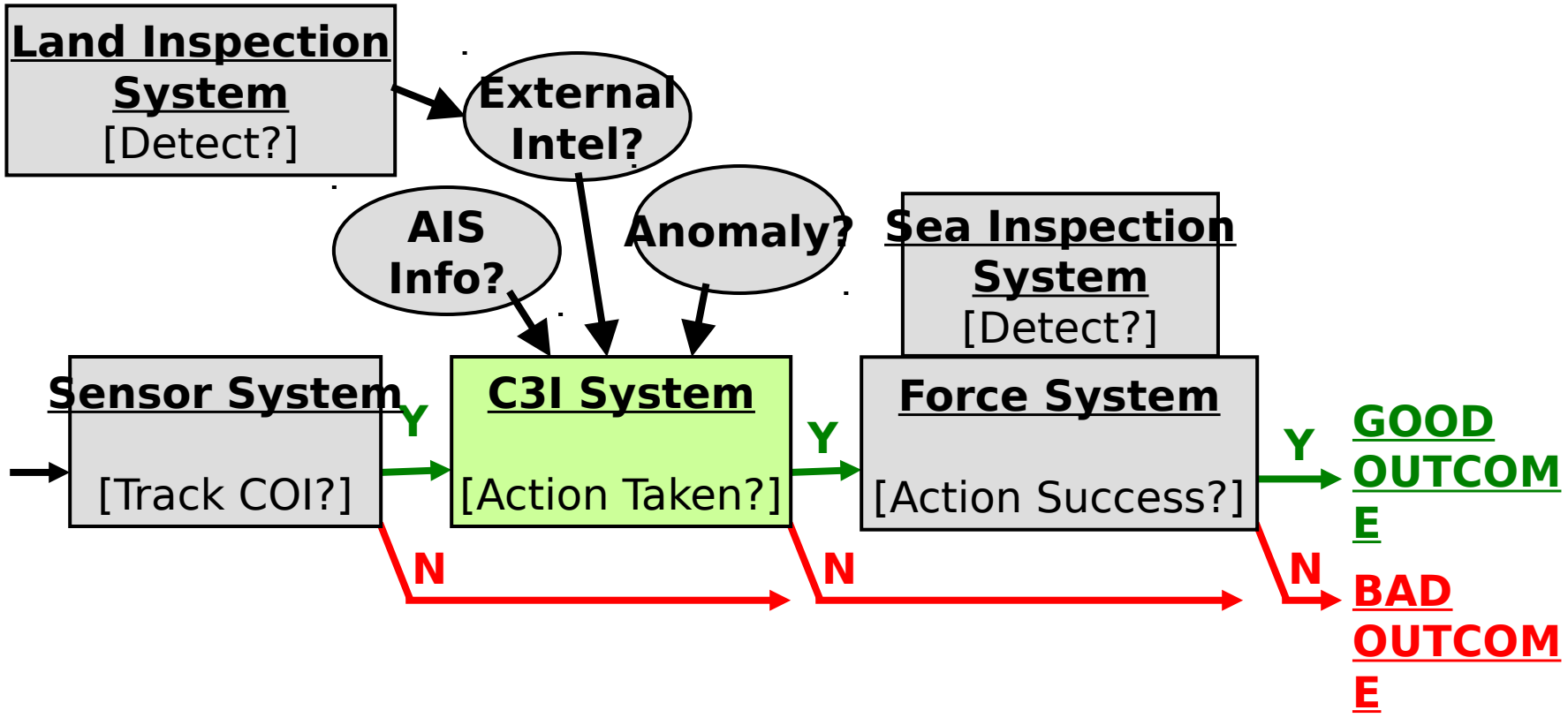
1500-1600 Response Force System

C3I Group



MAJ Russ A. Wyllie, USA

MDP System Operational Architecture



C3I Agenda

- Objectives/Requirements
- Functional Decomposition
- Alternatives (TDSI)
- Design Factors
- Model Overview
- Results
- Insights/Recommendations

NPS MDP Study System Insights

Sensors

- Current System is inefficient – better performance available at same cost

C3I

- Common Operating Picture and Data Fusion Centers drive C3I performance

Force Response

- Current Sea Marshal program is effective
- Point defense is key to protecting merchant ships from attack

C3I Group Objectives

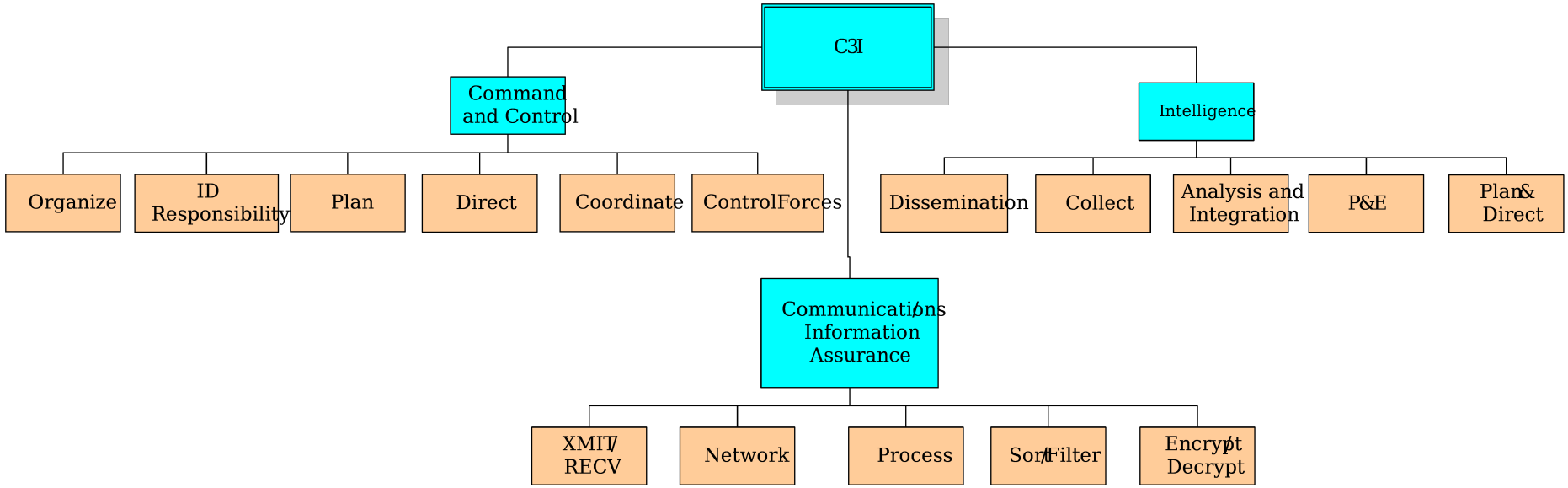
- Evaluate Command and Control and Intelligence (data fusion) System Capabilities
- Identify Communications network components linking Sensors and C3I system
- Identify appropriate level of Information Assurance for MDP system.
- Recommend system alternatives to improve C3I performance.

C3I System Requirements

- Minimum Analysis Time (Required to make Decision)
- Maximum Correct Decision
  - % P(Decide Act | Trigger Event)
- Minimum Incorrect Decision
  - % P(Decide Act | No Trigger Event)
- Communications Network Available 24/7

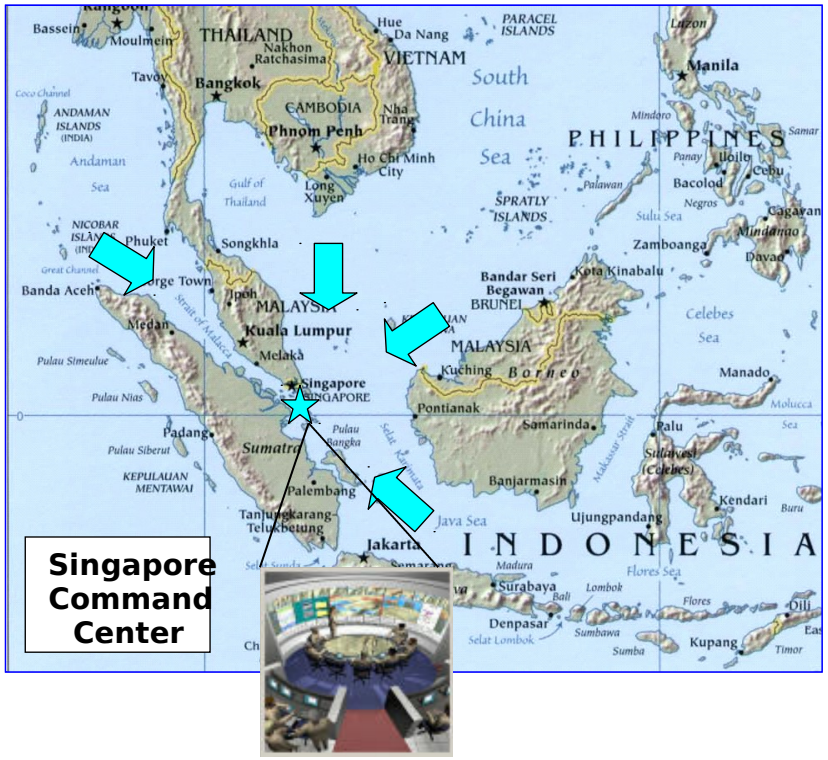
C3I Functional Decomposition

High Level Functions and Sub-Functions



“As–Is” C3I System

- **Singapore Primary Maritime Domain C2/Intel**
  - Independent Operations
  - Territorial Responsibility
- **Reliance on Electronic Intelligence Collection**
  - Sensor Data
  - Limited Correlation
  - Sequential Processing and Queuing
- **Communications**
  - Fixed infrastructure
  - Non-redundant

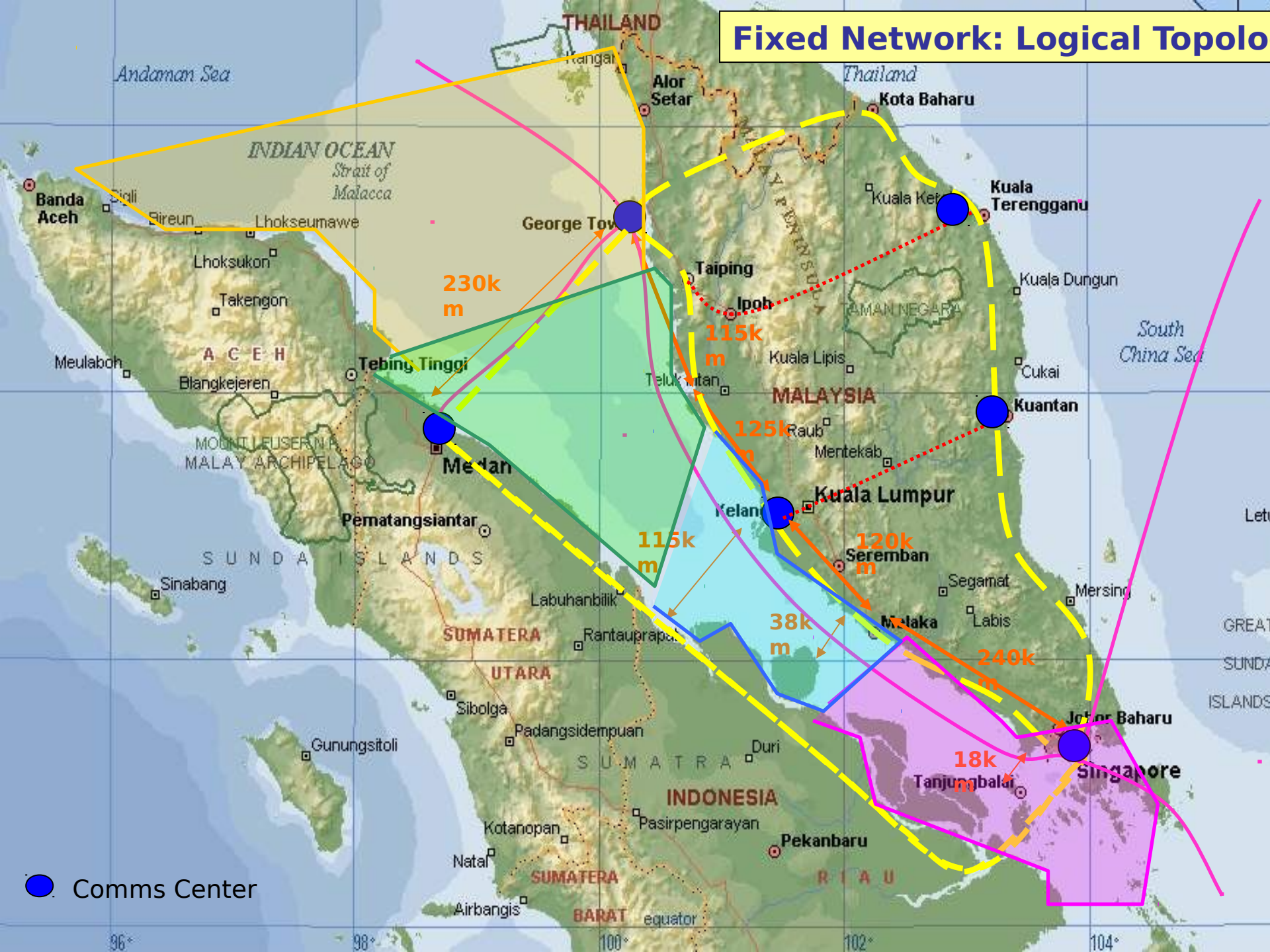


C3I Alternatives Generation

Communications Brief

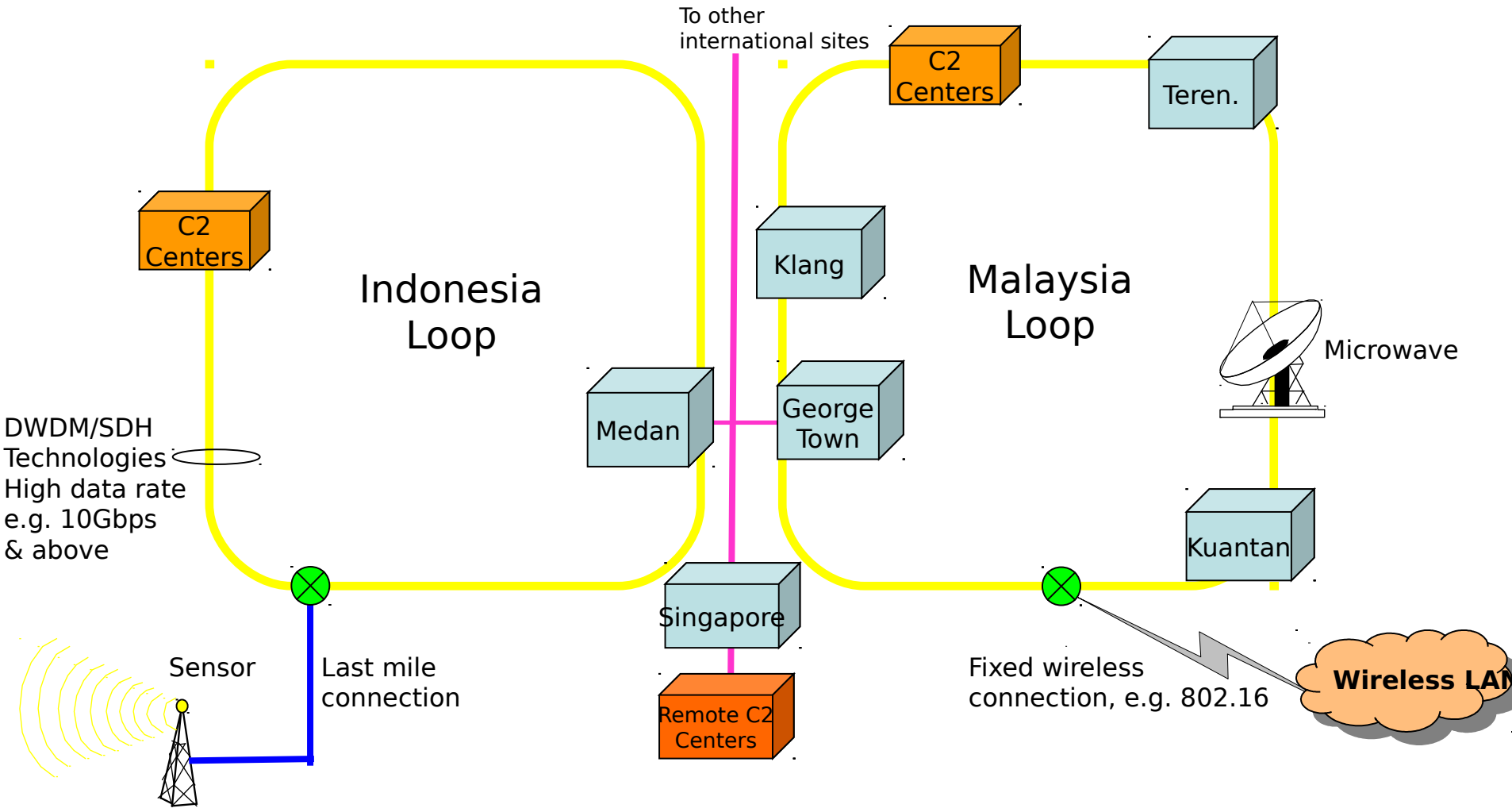
By
TDSI Comms Track

Members:
Tat Lee, LIM
Hong Siang, TEO
Cheng Kiat, TEO
Swee Jin, KOH


Fixed Network: Logical Topolo
THAILAND
Andaman Sea
Thailand
Alor Setar
Kota Baharu
INDIAN OCEAN
Strait of Malacca
Banda Aceh
Sigli
Sireun
Lhokseumawe
George Tow
Kuala Ke
Kuala Terengganu
Lhoksukon
Takengon
Taiping
Ipoh
Kuala Dungun
TAMAN NEGARA
230k m
115k m
South China Sea
A C E H
Meulaboh
Tebing Tinggi
Blangkejeren
Kuala Lipis
Cukai
MALAYSIA
Kuantan
MOUNT LEUSER NA
MALAY ARCHIPELAGO
Medan
125k m
Raub
Mentekab
Kuala Lumpur
Pematangsiantar
115k m
120k m
Seremban
S U N D A I S L A N D S
Sinabang
Segamat
Labuhanbilik
Melaka
Labis
38k m
SUMATERA
UTARA
Rantauprapat
240k m
Sibolga
Padangsidempuan
Gunungsitoli
Duri
18k m
S U M A T R A
Tanjungbalai
Singapore
INDONESIA
Kotanopan
Pasirpengarayan
Pekanbaru
Natal
SUMATERA
R I A U
Airbangis
BARAT
equator
96°
98°
100°
102°
104°
Comms Center

Fixed Network: Logical Topology

Backbone Fiber Optics Infrastructure



Fixed Network

Alternative Communications Link (Microwave)

- Preferred frequency 7.5 GHz, proposed link distance per hop of < 30 km.
- Alternate frequency 15 GHz, proposed link distance per hop of < 10 km.
  - Shorter distance per hop => more equipment
  - Lower availability rates (99.9%)

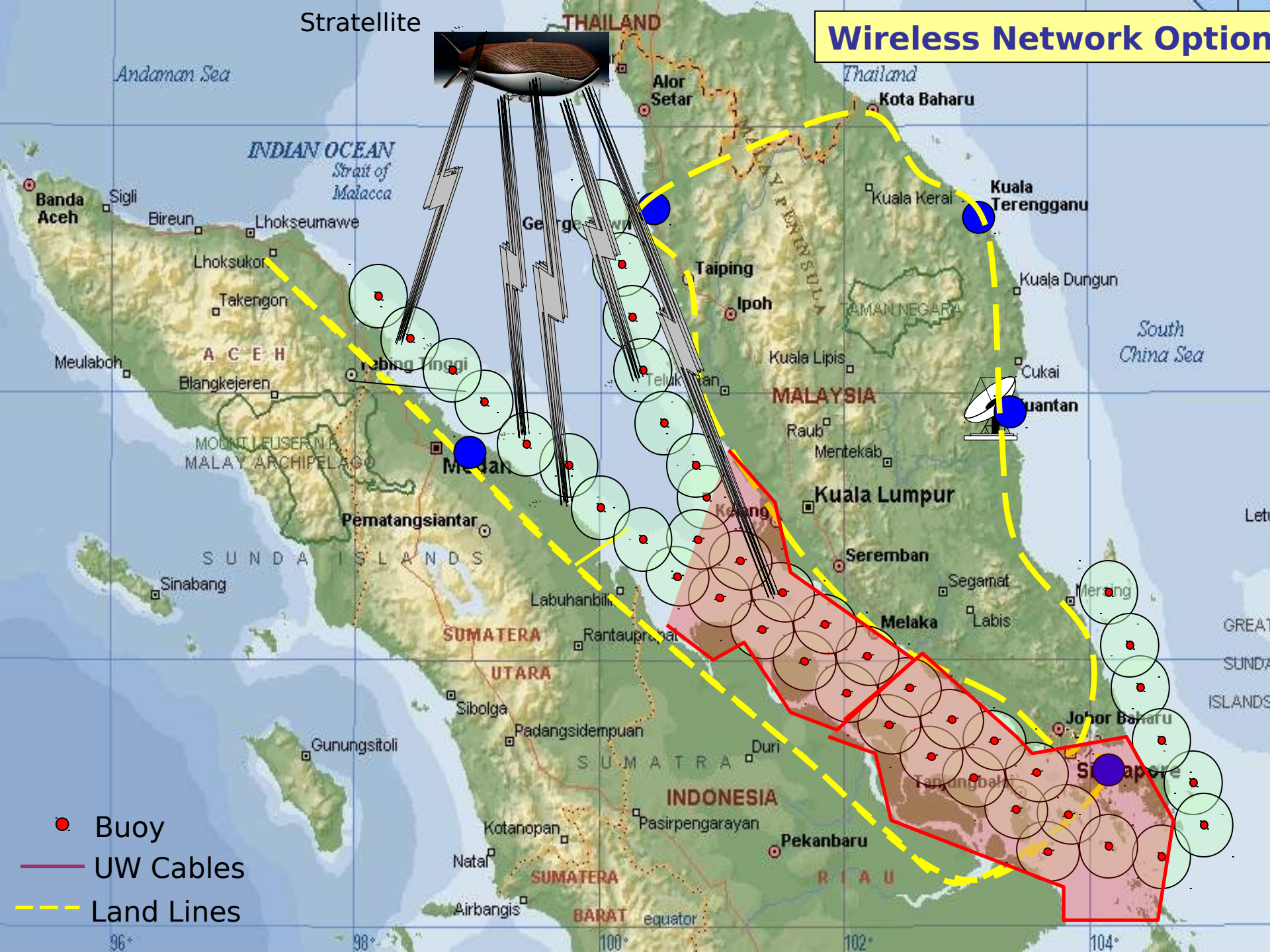
	Frequency	7.5 GHz	Wavelength	0.04m	Frequency	15 GHz	Wavelength	0.02m
Dist (km)	Availability (Rainfall)	Downtime (seconds)	Availability (Terrain)	Downtime (seconds)	Availability (Rainfall)	Downtime (seconds)	Availability (Terrain)	Downtime (seconds)
10	>99.993%	<181	100.000%	1	99.9259%	1920	100.000%	3
20	>99.993%	<181	99.9993%	35	99.8265%	4497	99.9985%	80
30	99.9910%	232	99.9949%	264	99.7417%	6694	99.9883%	608
40	99.9871%	334	99.9786%	1111	99.6670%	8630	99.9506%	2563
50	99.9832%	435	99.9623%	2390	99.5948%	10399	99.8491%	7821
60	99.9794%	534	99.8573%	8455	99.5348%	12059	99.6246%	19461

Parameters:
Antenna Size: 1.2m
Antenna Gain: 37.5dB
Tx Power: 25dBm
ERP: 60.7dBm

Calculations based on:
-Climate: Maritime temperate, coastal or high humidity and temperate climatic regions
-Rainfall Zone: P (145mm/hr)

Wireless Network Topology

- **Concept 1: Buoys as Wireless LAN Base Stations**
  - Buoys deployed along the straits
    - Solar powered
  - **Backhaul options:**
    - Fixed Wireless e.g. 802.16
      - Point-to-point wireless links to shore
      - "Stratellite" as rebro-stations
    - U/W cables provide power and connectivity
  - **Limitations:** May require many cells, high cost
  - **Strengths:** Ubiquitous network coverage


Stratellite
Wireless Network Option
THAILAND
Andaman Sea
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Alor Setar
Kota Baharu
INDIAN OCEAN
Strait of Malacca
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Sigli
Bireun
Lhokseumawe
Lhoksukon
Takengon
Kuala Kerai
Kuala Terengganu
Taiping
Ipoh
Kuala Dungun
TAMAN NEGARA
South China Sea
A C E H
Meulaboh
Blangkejeren
Kuala Lipis
Cukai
MALAYSIA
Raub
Mentekab
MOUNT LEUSER NA
MALAY ARCHIPELAGO
Kuala Lumpur
Pematangsiantar
S U N D A I S L A N D S
Seremban
Sinabang
Segamat
Labis
Melaka
SUMATERA
UTARA
Sibolga
Padangsidempuan
Gunungsitoli
Duri
S U M A T R A
INDONESIA
Kotanopan
Pasirpengarayan
Pekanbaru
Natal
SUMATERA
R I A U
BARAT
Airbangis
equator
96°
98°
100°
102°
104°
Buoy
UW Cables
Land Lines

Wireless Network Topology

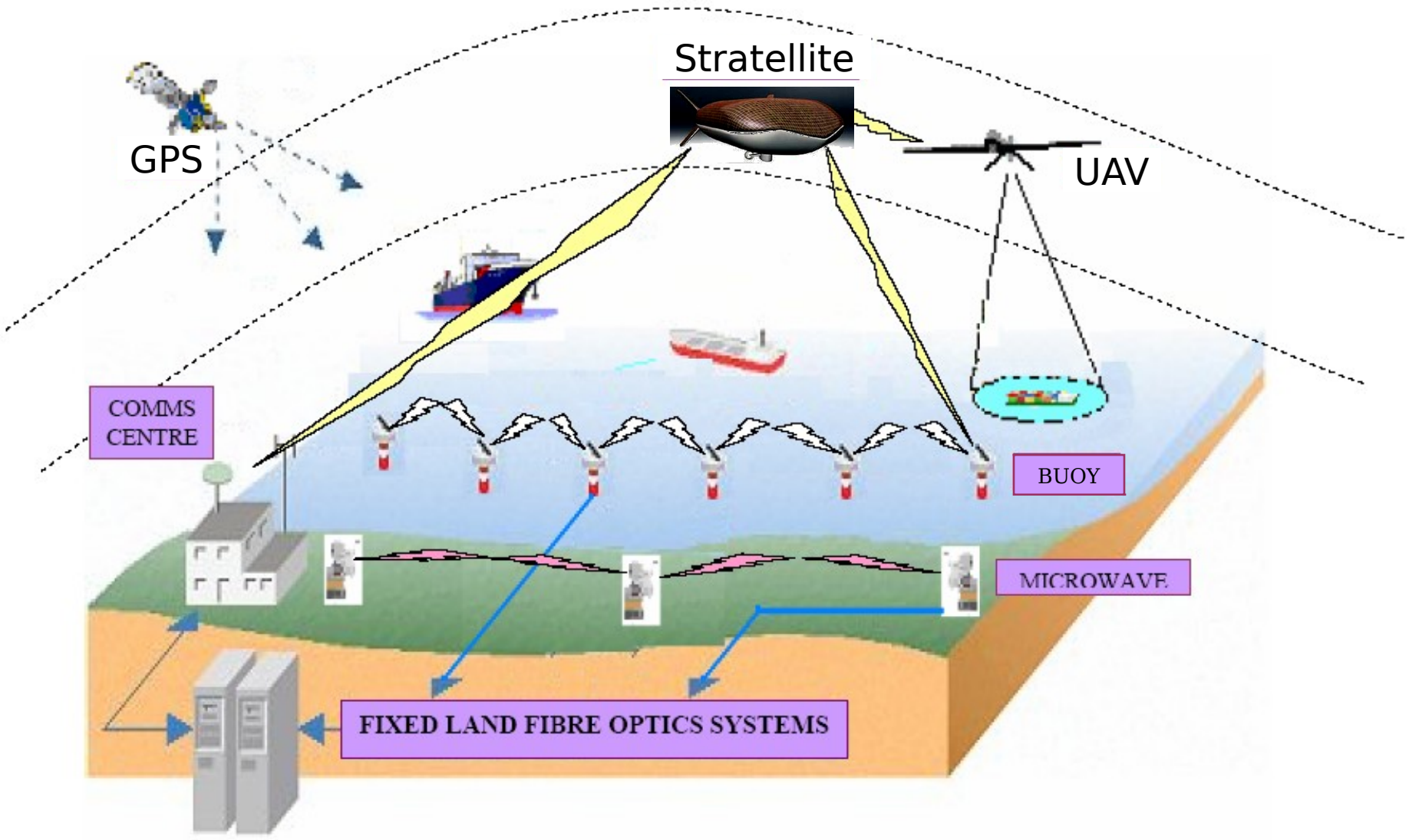
- **Concept 2: Ad-hoc Network via mobile platforms**
  - Mainly used to support task force
  - Wireless LAN Breadcrumb supported by UAV as routing nodes to fixed wireless nodes (e.g. 802.16)
  - **Limitations:** No permanent coverage
  - **Strengths:** Cheap and proven prototype

Bandwidth Requirements

- Baseline Network Bandwidth (per C2 site/ sector COMCEN)
  - Radars (Assume 20 sites)
  - Automatic Identification System (AIS) (2 channels)
  - Voice & Data (30 channels)
- Ad-hoc Network Bandwidth (Task force)
  - Image (video/IR)
    - Assume 5 UAV in a region at any one time
    - Frame rate – 30 frames/sec (NTSC)
  - Voice & Data (Assume 20 platforms with 2 channels)

- Estimated backbone bandwidth requirement:
  - Approx 250Mbps (c.f. OC-3: 155Mbps)
  - Excess bandwidth for RCMS, VPN, SCADA, etc.
- Scalable Fiber Optic Network Technology
  - Up to multiples of OC-3 in one OC-48 (aka STM-16) ring

Conceptual Communications Linkages



Information Assurance Strategy : Defense in Depth

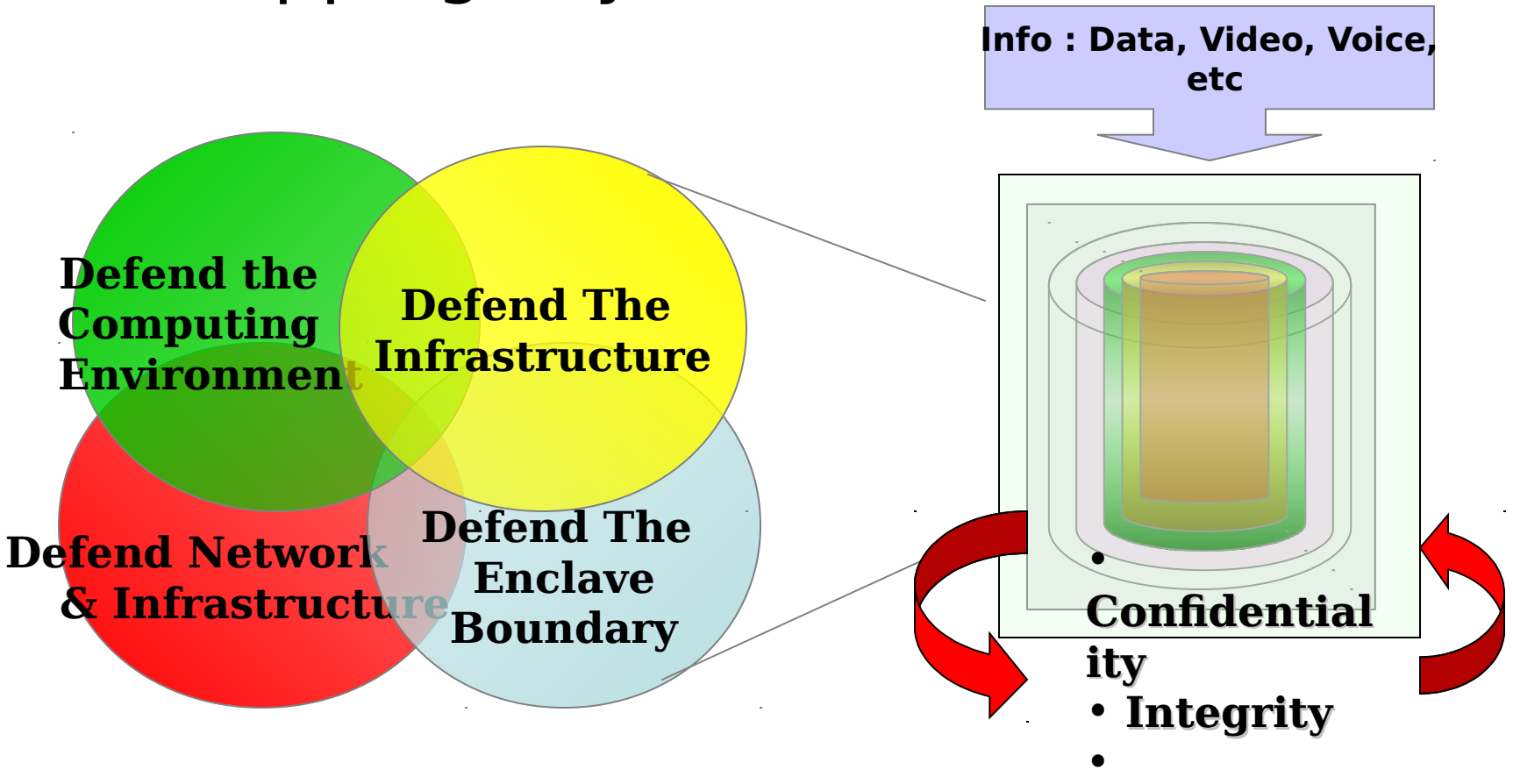
Presented by : CPT CHAY CHUA

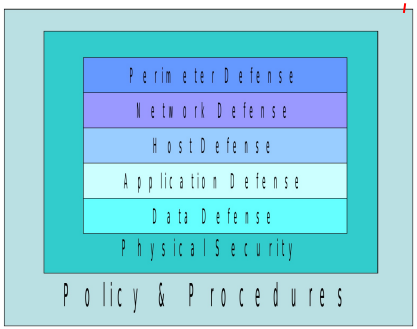
Team Members: Mr CheeMun Ng
: Mr NaiKwan Tan

Information Assurance

IA Strategy: Defense In Depth

- Layers of Defense
- Overlapping Layers of Protection





Defense in Depth Security Model

Perimeter Defense:
- Public Internet Boundary

Interconnect

Perimeter Defense

- Network access
- Quarantine Control
- Personnel Firewall

Network Defense:
- Network Intrusion Filter
- Inter-Community of Interest and Intra-Community of Interest

Interconnect

Network Defense

- RADIUS & PKI
- IPSec
- Network Segmentation

Host Defense:
- End System
- Securely configured OS

Interconnect

Host Defense

- OS hardening
- Patch management
- Antivirus
- Distribution Firewall
- Effective auditing

Application Defense
- Network Access Controller

Interconnect

Application Defense

- IIS hardening
- Exchange hardening
- SQL hardening

Data Defense
- Data at rest encryption

Interconnect

Data Defense

- Access Control List
- Encryption
- Backup
- Restore Strategy

Physical Defense
- Locks
- Guards

Policy & Procedure
- End User Training
- User Awareness

Perimeter Defense

Network Defense

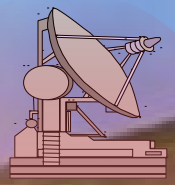
Host Defense

Application Defense

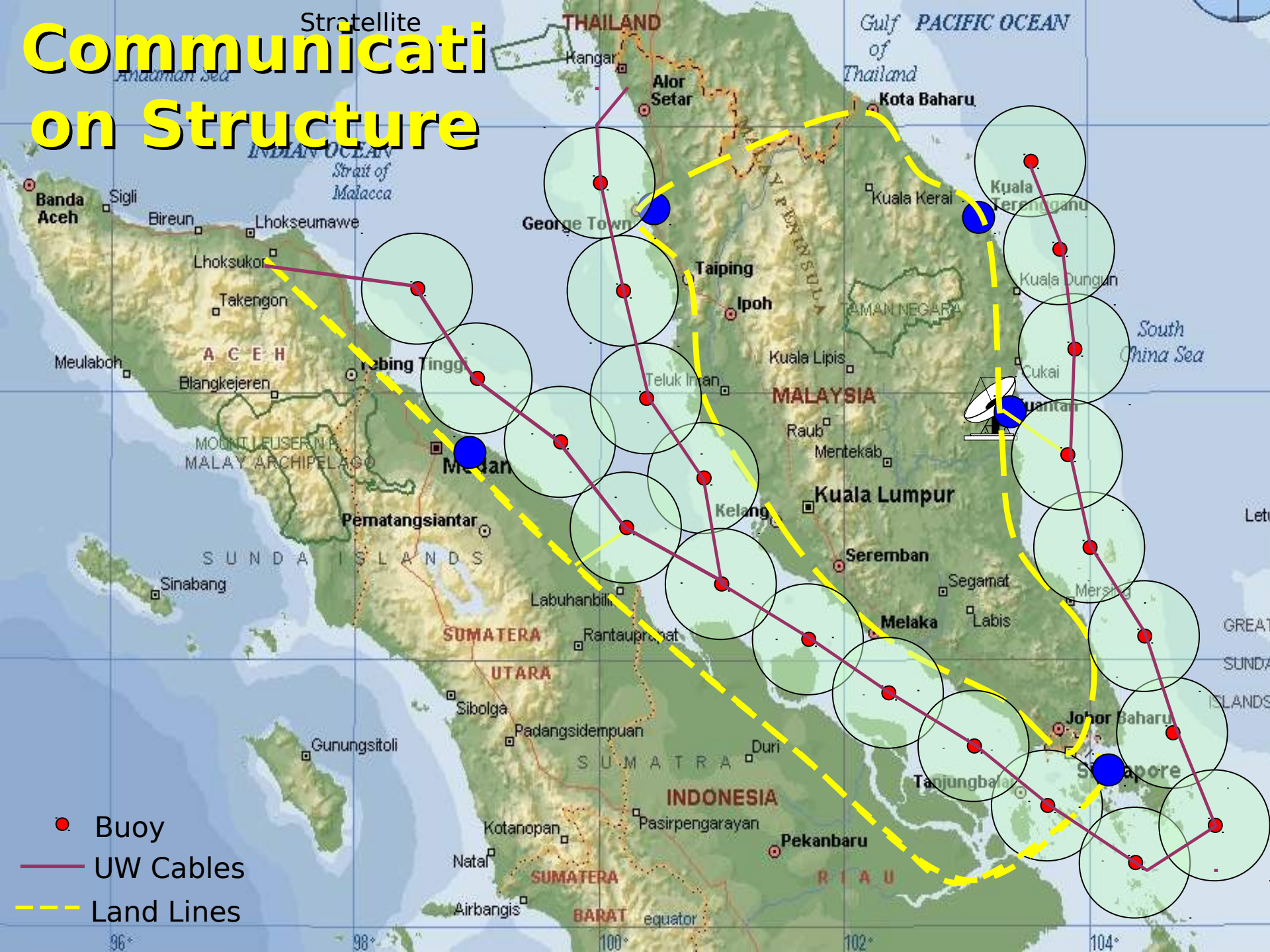
Data Defense

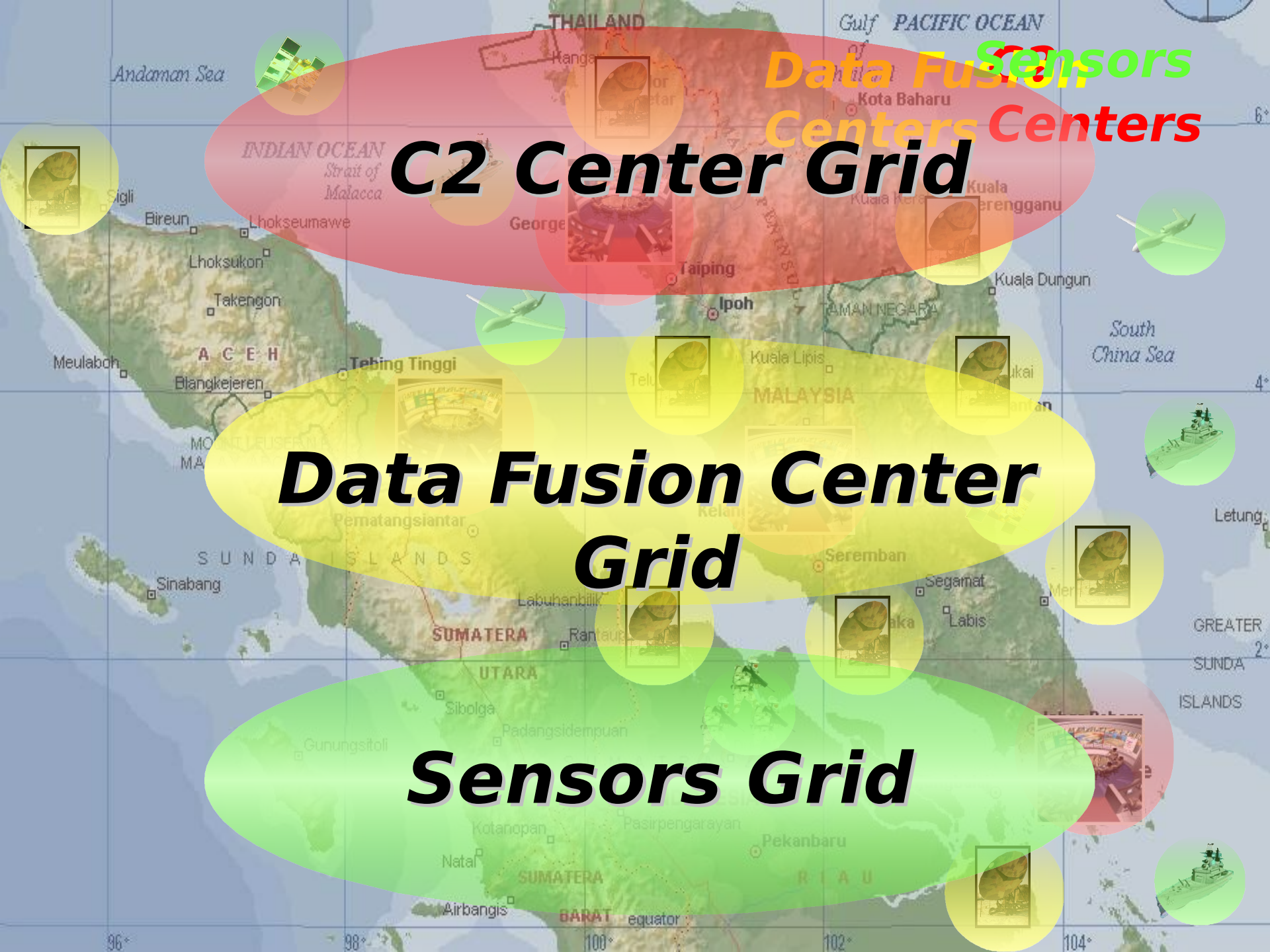
Physical Security

Policy & Procedures



Communication Structure




C2 Center Grid
Data Fusion Centers
Sensors Centers
Data Fusion Center Grid
Sensors Grid
THAILAND
Andaman Sea
Gulf
PACIFIC OCEAN
INDIAN OCEAN
Strait of Malacca
Kota Baharu
Kuala Dungun
Taiping
Ipoh
TAMAN NEGARA
Kuala Lipis
MALAYSIA
South China Sea
Bireun
Lhokseumawe
Lhoksukon
Takengon
A C E H
Meulaboh
Tebing Tinggi
Blangkejeren
Pematangsiantar
S U N D A I S L A N D S
Sinabang
Seremban
Segamat
Labis
Labuhanbilik
SUMATERA
UTARA
Sibolga
Padangsidempuan
Gunungsitoli
Kotanopan
Natal
Pasirpengarayan
Pekanbaru
SUMATERA
BARAT
R I A U
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equator
GREATER SUNDA ISLANDS
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96°
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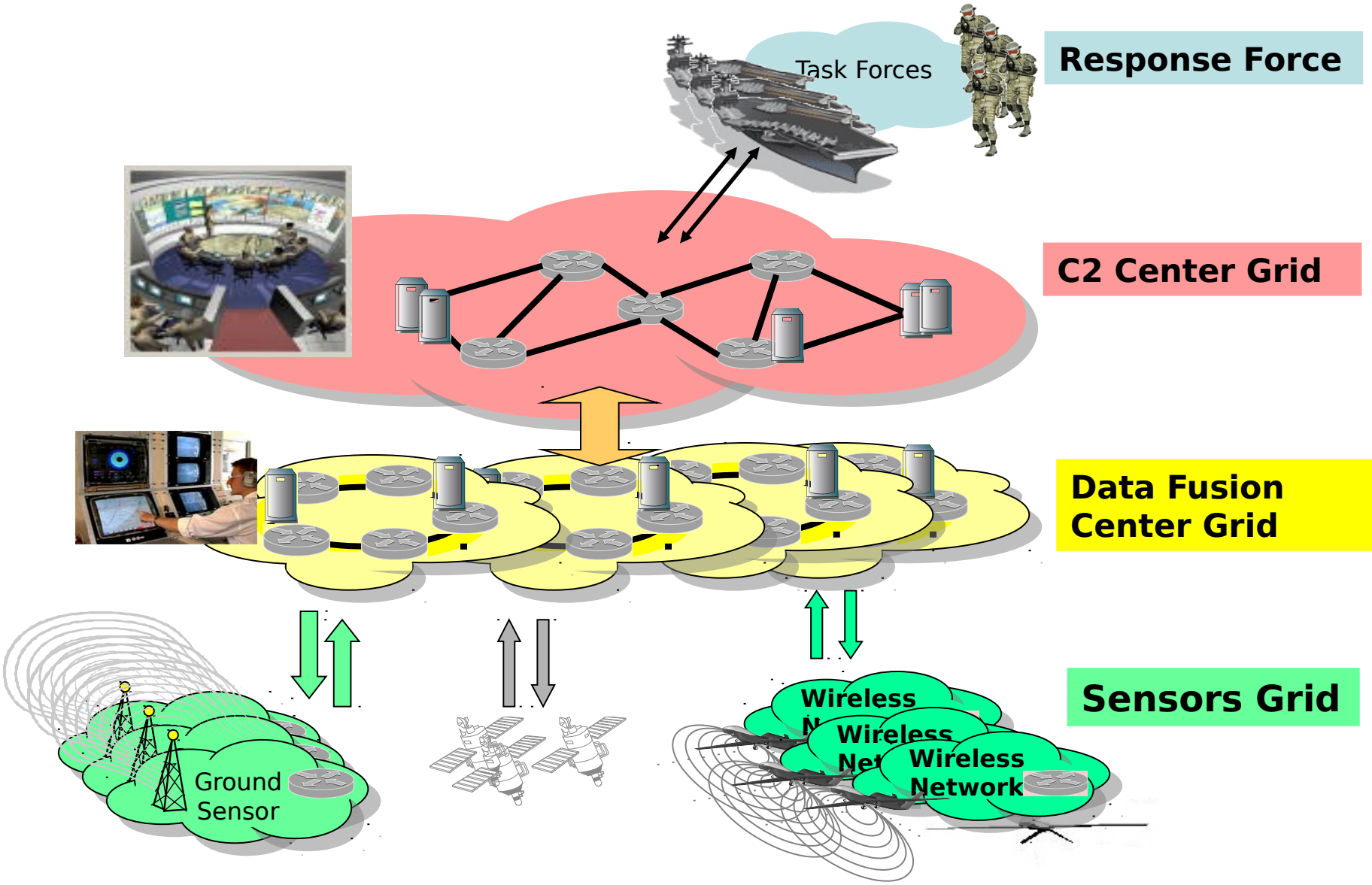
4°
2°

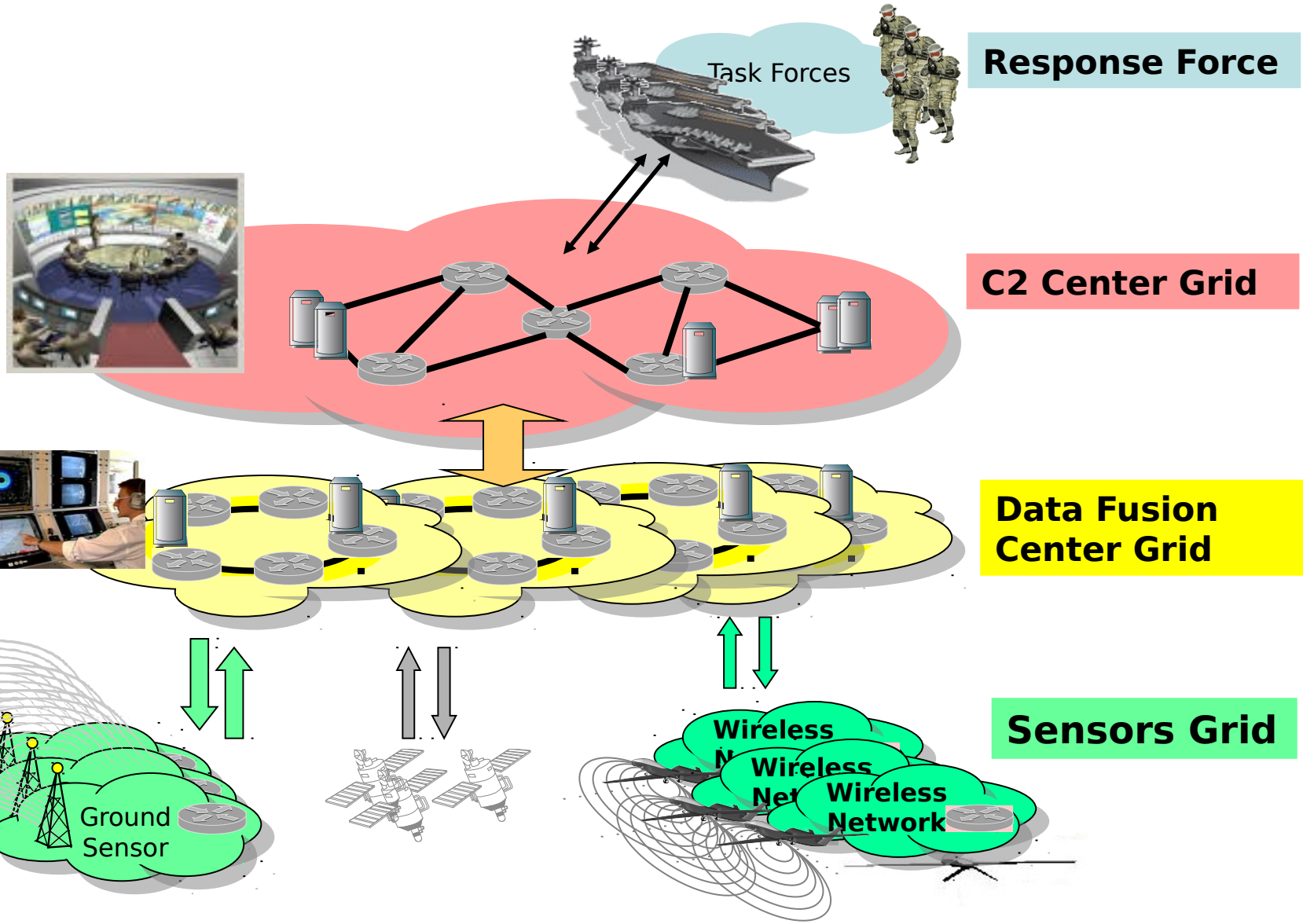
Logical Connectivity



Potential Cyber Threats

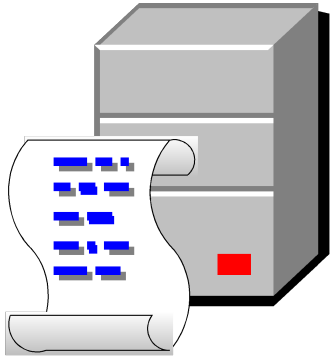
- **Categories of threats:**
  - ***Malicious Programs*** – Malevolent programs reproduce self to move between systems without authorization, or subvert the system by providing trap-doors into the systems.
  - ***Users' Error***– Authorized user may create unintentional errors that cause breakdown to the whole system/operations.
  - ***Professional Hackers*** – Seasonal attackers who break into systems for vandalism or theft of information
  - ***Criminals*** – Trespassers who read and distort information without granted authority.
  - ***Terrorists*** – Organized hacking and eavesdropping on network traffic to gather/steal intelligence for their destructive attacks
  - ***State-Sponsored Attack*** – Hostile countries may sponsor attacks to infiltrate and sabotage the system

Logical Connectivity



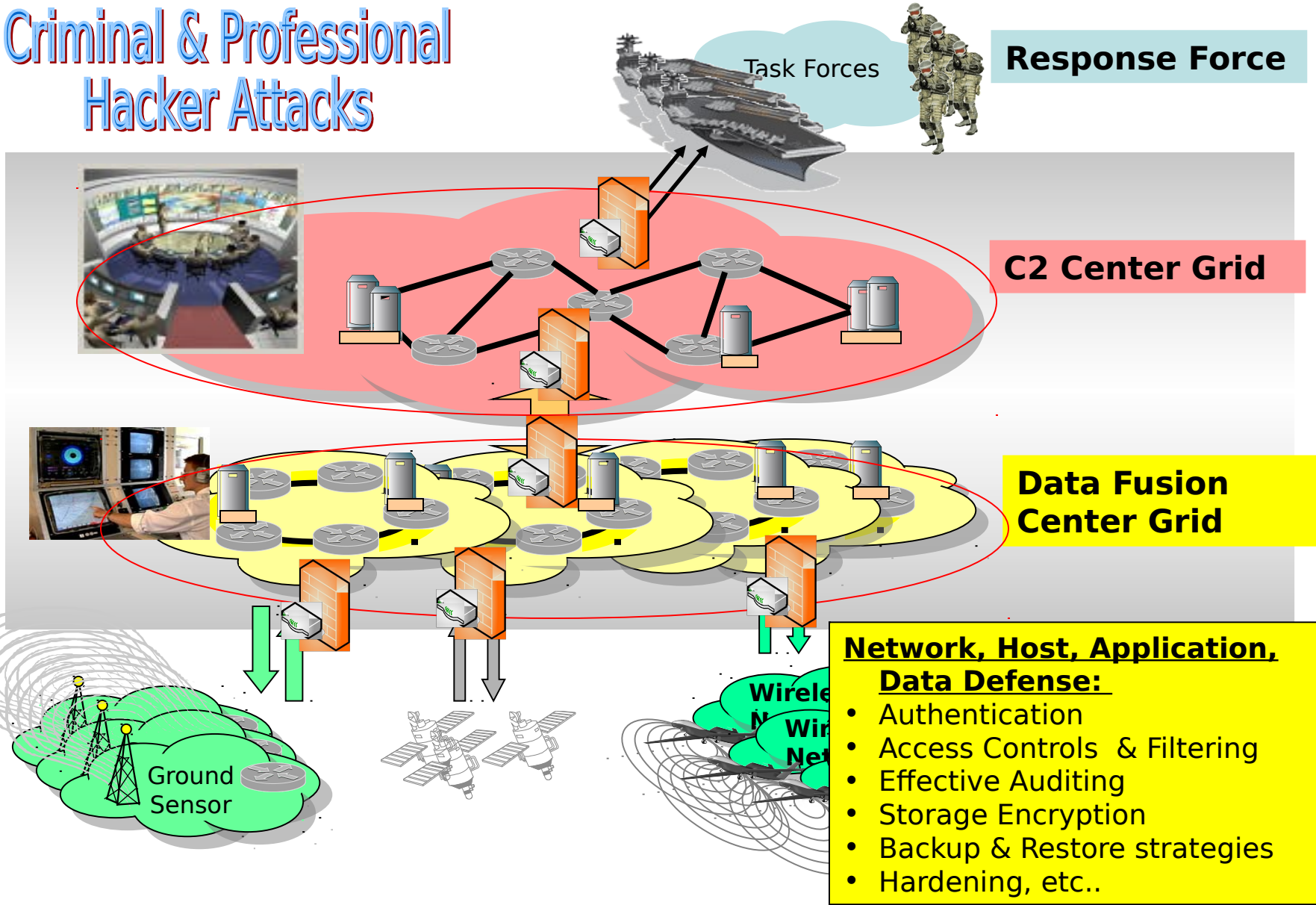
Countermeasures: Policies & Training

- **Objectives:**
  - ***Protect against Malicious Programs***
  - ***Prevent User Errors***

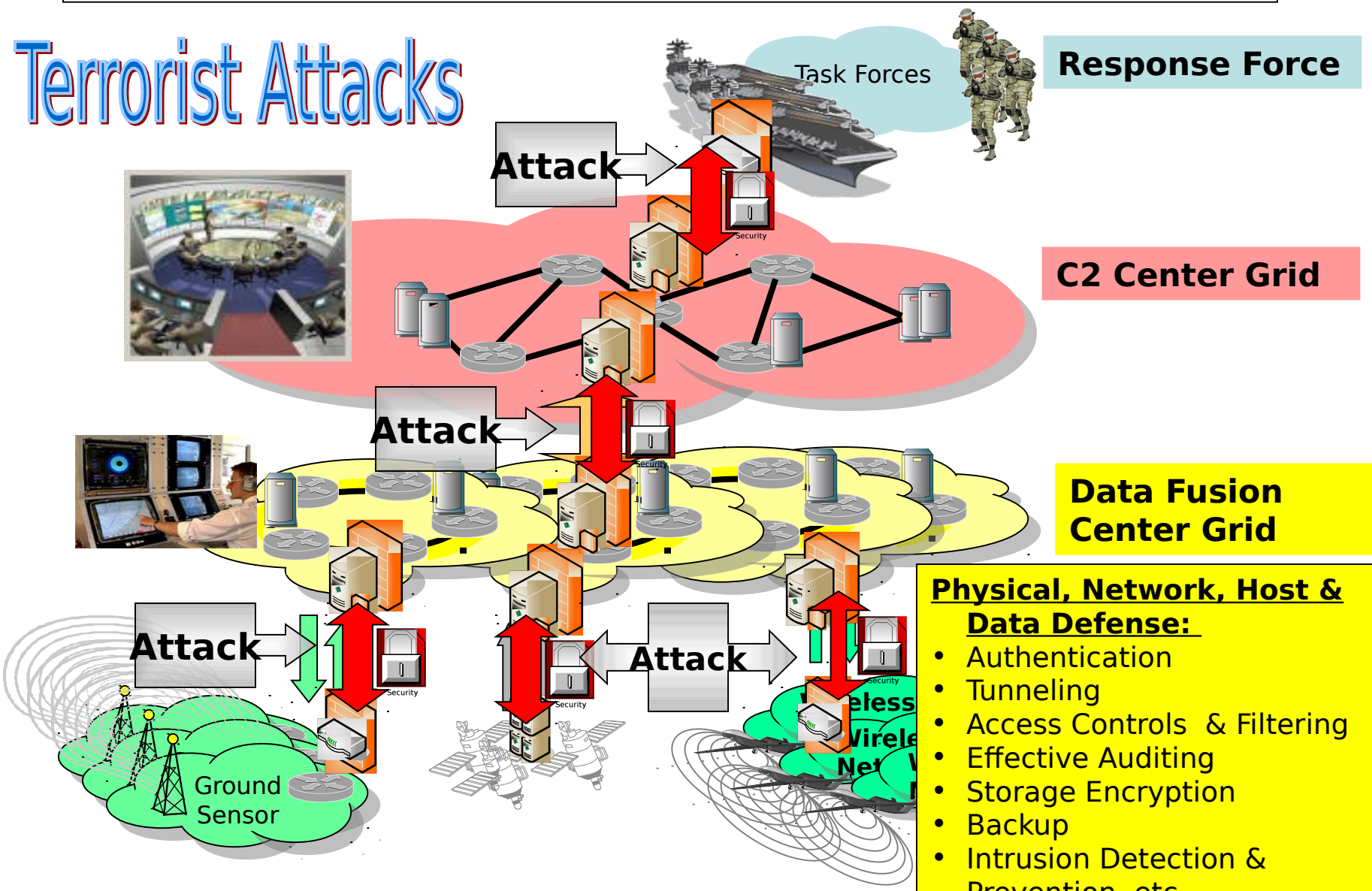


- **Mechanisms *:***
  - ***DoD IA Directives and implementations:***
    - ***DoD Directive 8100.1 : Global Information Grid(GIG) overarching Policy***
    - ***DoD Directive 8500.1: Information Assurance***
    - ***DoD Instruction 8500.2: IA Implementation***
    - ***DoD Instruction 8100.2 : Use of Wireless Device, Services & Technologies in DoD GIG***
  - ***Provide security training for all users***

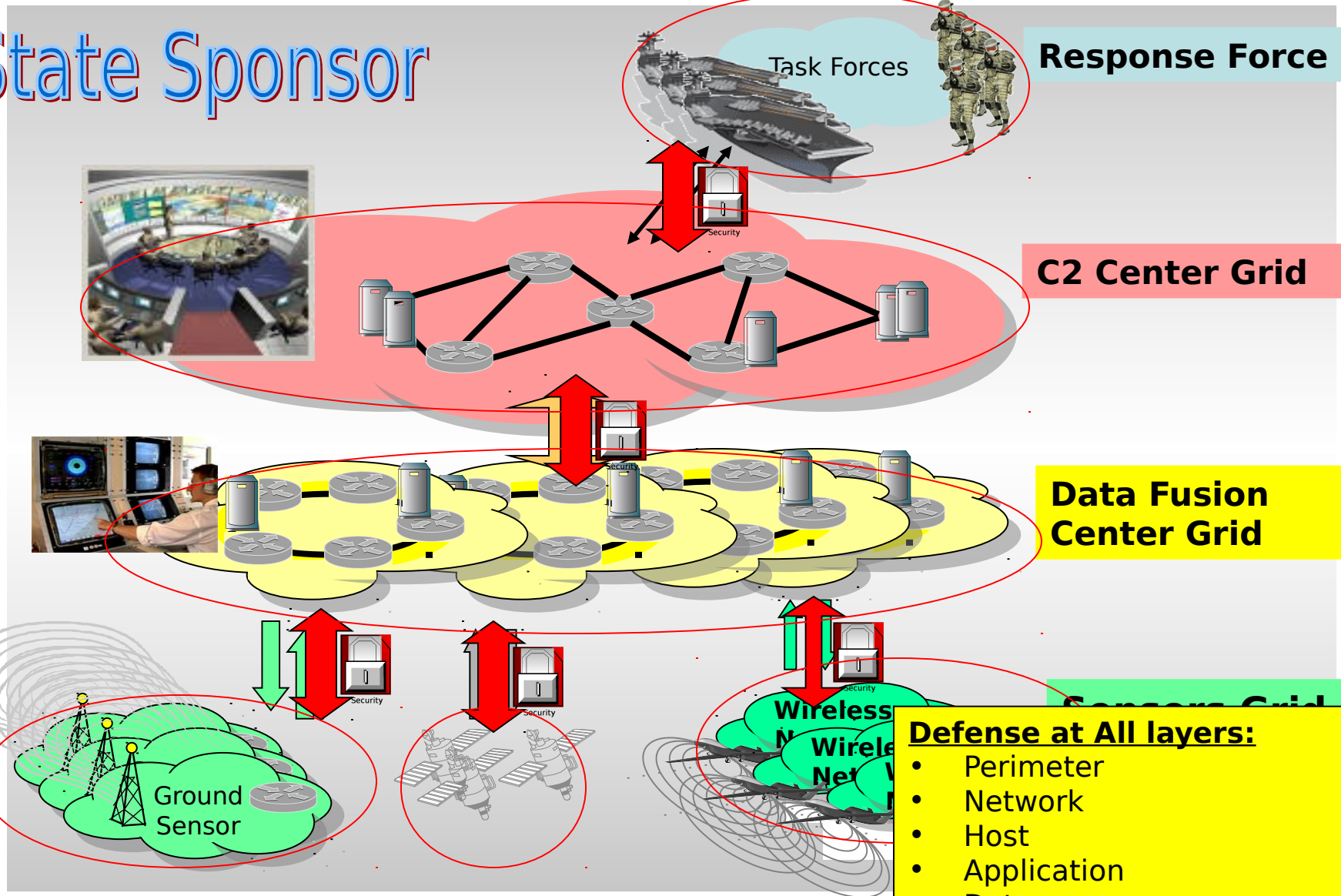
Countermeasures Against Criminal & Professional Hacker Attacks



Countermeasures Against Terrorist Attacks



Countermeasures Against State Sponsored Attacks



Summary

- **Policies and Procedure**
  - Provide End User Training
  - Increase User Awareness
  - Continuously Review Policies and Procedures to meet the new adversaries

- **Defense-in-depth strategy**
  - Secure physical and logical perimeters
  - Defend Network, Host, Application and Data

Conclusion

- **No Perfect Security**
  - Threat is pervasive and ever changing
  - Protections must evolve to meet these challenges
  - Implement layered defense to deter adversaries

Reference

- Picture from
  - **homepage.mac.com / g3head/hacksgallery.html**
  - http://www.cranfieldaerospace.com/applications/observer_details.htm

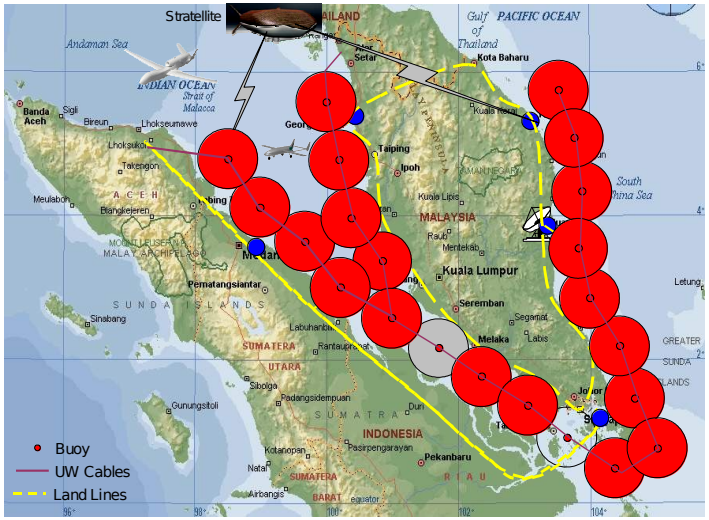
C3I Alternatives Overview

- **ALT 1: Regional Architecture**
  - –Two C2/Data Fusion Center
  - –Network Centric Communications
  - –Reliance on Electronic Intelligence Collection

- **ALT 2: Network Centric + Data Fusion Cells**
  - –Four Regional C2/Intel Centers
  - –Nine Data Fusion Cells
  - –Intelligence Network 13 Intel/HUMINT Collection Nodes
  - –Network Centric Communications

C3I Alternative 1
Regional Architecture

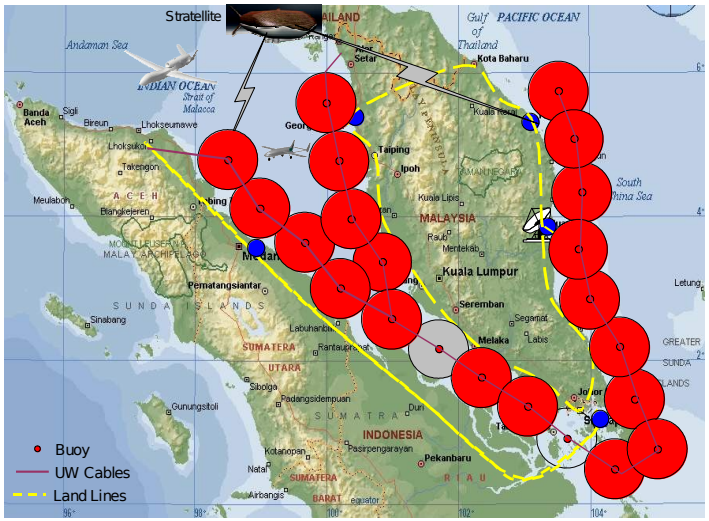
- **Two C²/Data Fusion Centers**
  - Network Centric
  - Large AOR
- **Reliance on Electronic Intelligence Collection**
  - Sensor Data
  - Sequential Processing and Queuing
- **Communications**
  - Fiber Optic Backbone, Networked Maritime Wireless Communication Buoy Stations, Stratellites
  - Unmanned fixed wing UAVs
  - Layered, graceful degradation



C3I Alternative 2

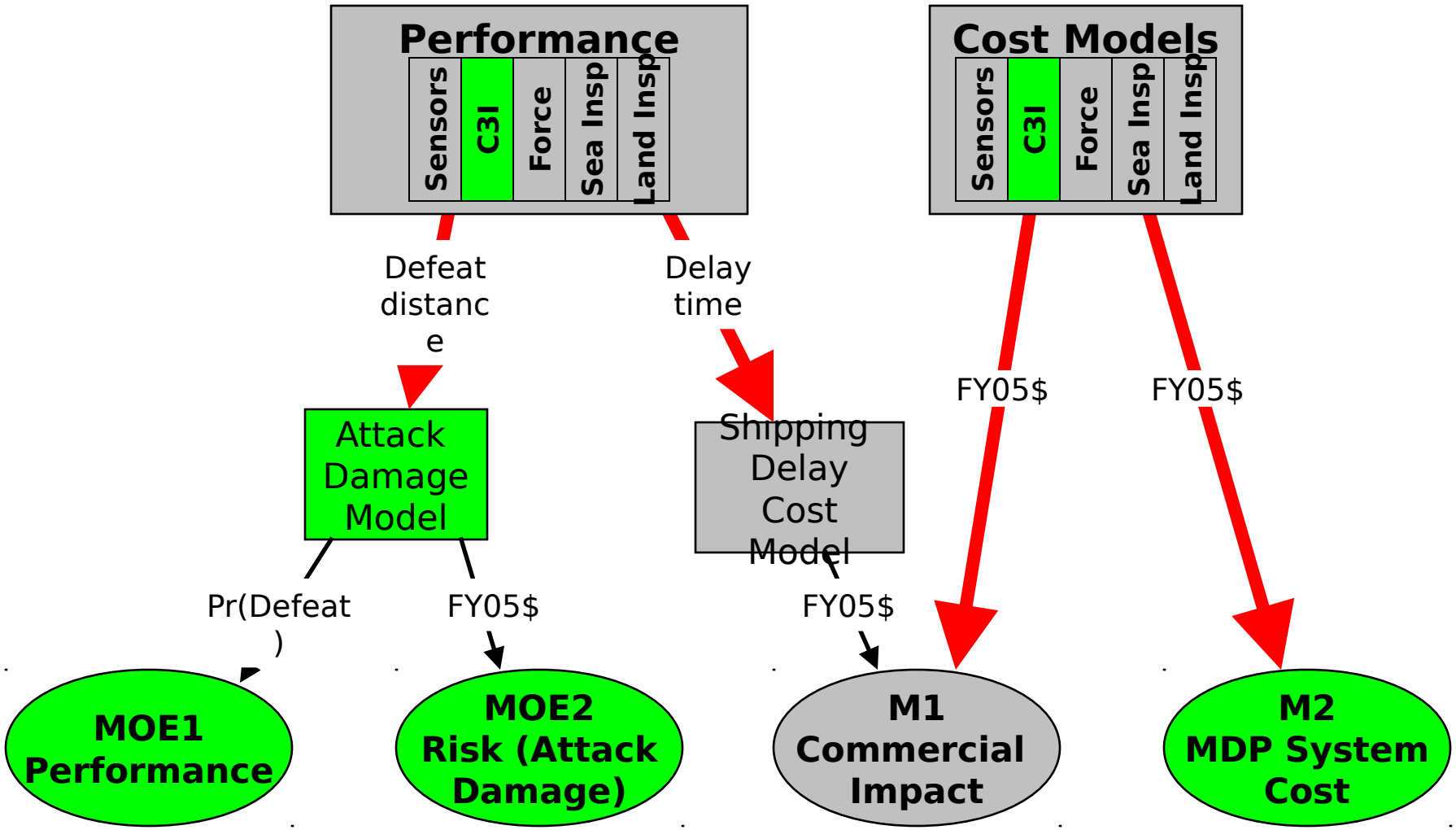
Network Centric + Data Fusion Cells

- **4 Regional C2/Intel Centers**
  - 9 Data Fusion Cells Creates CIP
  - Creates COP
  - Self-Synchronizing w/Distributed Authority
- **Intelligence Network 13 Intel/HUMINT Collection Nodes**
  - Localized Intelligence Expertise (Inland)
  - Social Networks and All-source collection
  - Maximize “Trigger Event” Opportunities
- **Communications**
  - Fiber Optic Backbone, Networked Maritime Wireless Communication Buoy Stations, Stratelites
  - Unmanned fixed wing UAVs
  - Layered, graceful degradation



C3I Modeling

Overarching Modeling Plan



C3I Model Description & Assumptions

- **Approach**
  - **Two Models; “Timely” and “Informed”**
- **Models Used**
  - **EXTEND Model**
  - **Excel**
- **Assumptions**
  - **Only one decision can be made on each track.**
  - **Delays represent automation (0) or human (>0) in the loop**
  - **Data Fusion Cells and Command and Control Centers are collocated**
  - **An “informed” decision can be modeled by probabilities and the associated assigned scores**
  - **Decisions are based upon a perceived reality**

C3I System Factors

Held Constant

- Track Quality: P(track)
- Track Quality: P(fa)
- Position Error: CEP
- Presence/Quality :
  - Intelligence
  - AIS Info
  - Sea Inspect

Varied

- # Data Fusion Cells
- # C2 Centers
- Network Centric (Y/N)
- Intel Collection Nodes

C3I Performance Model Overview

Inputs

- # Data Fusion Cells
- # C2 Centers
- Network Centric (Y/N)
- Intelligence Collection Nodes

C3I "Timeliness" Model

Outputs

Analysis Time

- Presence/Quality:
  - Intelligence
  - AIS Info.
  - Sea Inspection

C3I "Informed" Model

Probability Correct Decision

C3I Modeling Results

C3I Modeling Factors

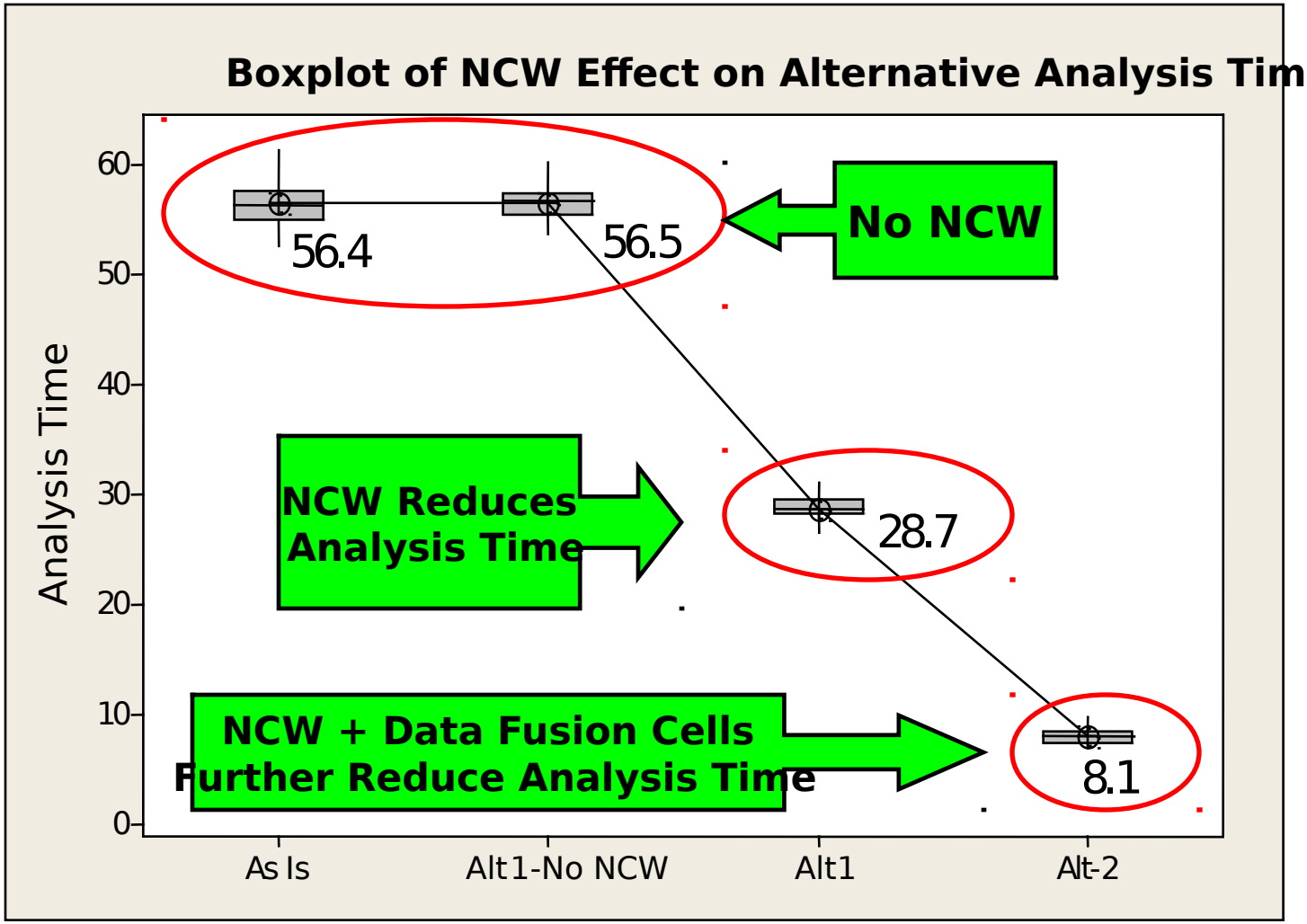
		Values		
Factors	**Values Evaluated**	**As-Is**	**Alt 1**	**Alt 2**
# C2 Centers	1,2,4	1	2	4
# Data Fusion Cells	1,2,9	1	2	9
Network Centric (Yes/No)	0,1	0	1	1
Intelligence Collection Nodes	0, 13	0	0	13
C2 Center Staffing Ratio	7:1, 5:1, 4:1	5:1	5:1	5:1

C3I Modeling Results

MOEs	As-Is	Alt 1	Alt 2
Analysis Time (Generic Time Unit)	56.40	28.70	8.10
P (Decide Act | Trigger Event)			
P(Inspect | WMD)	20%	35%	68%
P(Engage | Anomaly)	20%	35%	68%
P (Decide Act | No Trigger Event)			
P(Inspect | No WMD)	0.41%	0.32%	0.16%
P(Engage | No Anomaly)	0.49%	0.33%	0.21%
C3I System Cost (FY05$M)	541	1,593	2,922

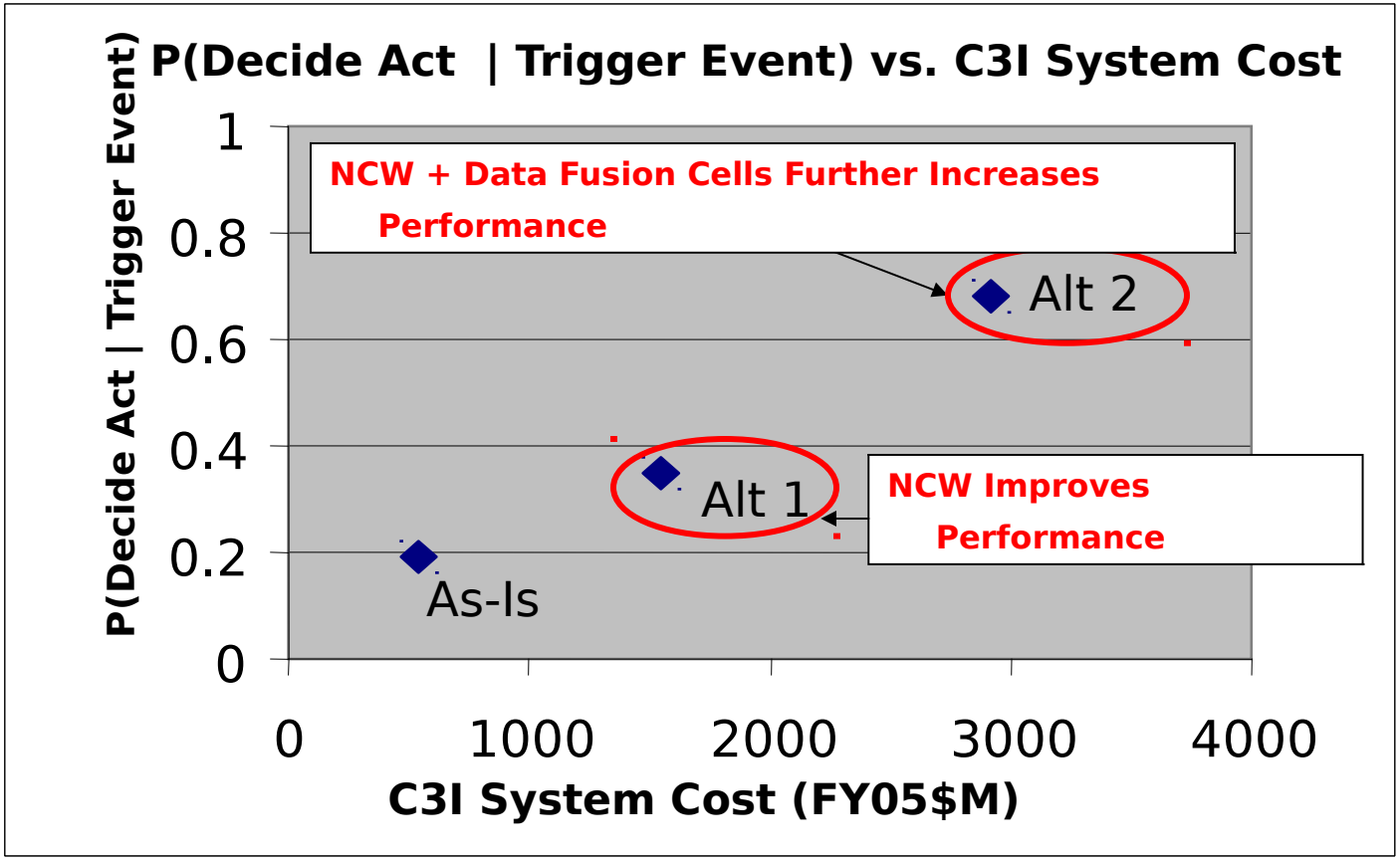
C3I Results Graphs

Timely Model Performance



C3I Results Graphs

P(Decide Act | Trigger Event) vs. Cost

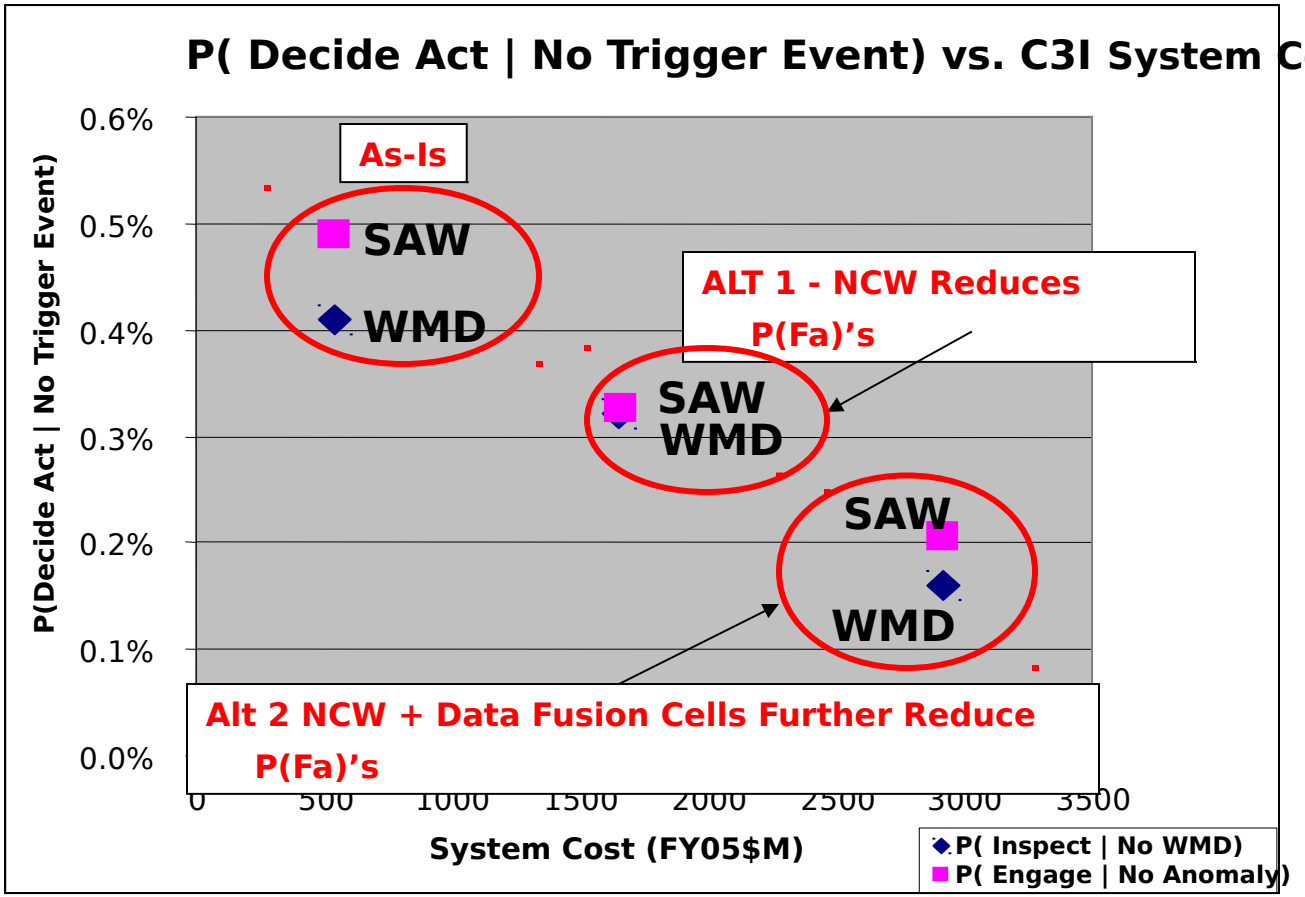


P (Decide Act | Trigger Event);

- **P (Decide Inspect | WMD)**
- **P (Decide Engage | Anomaly)**

C3I Results Graphs

P(Decide Act | No Trigger Event) vs. Cost

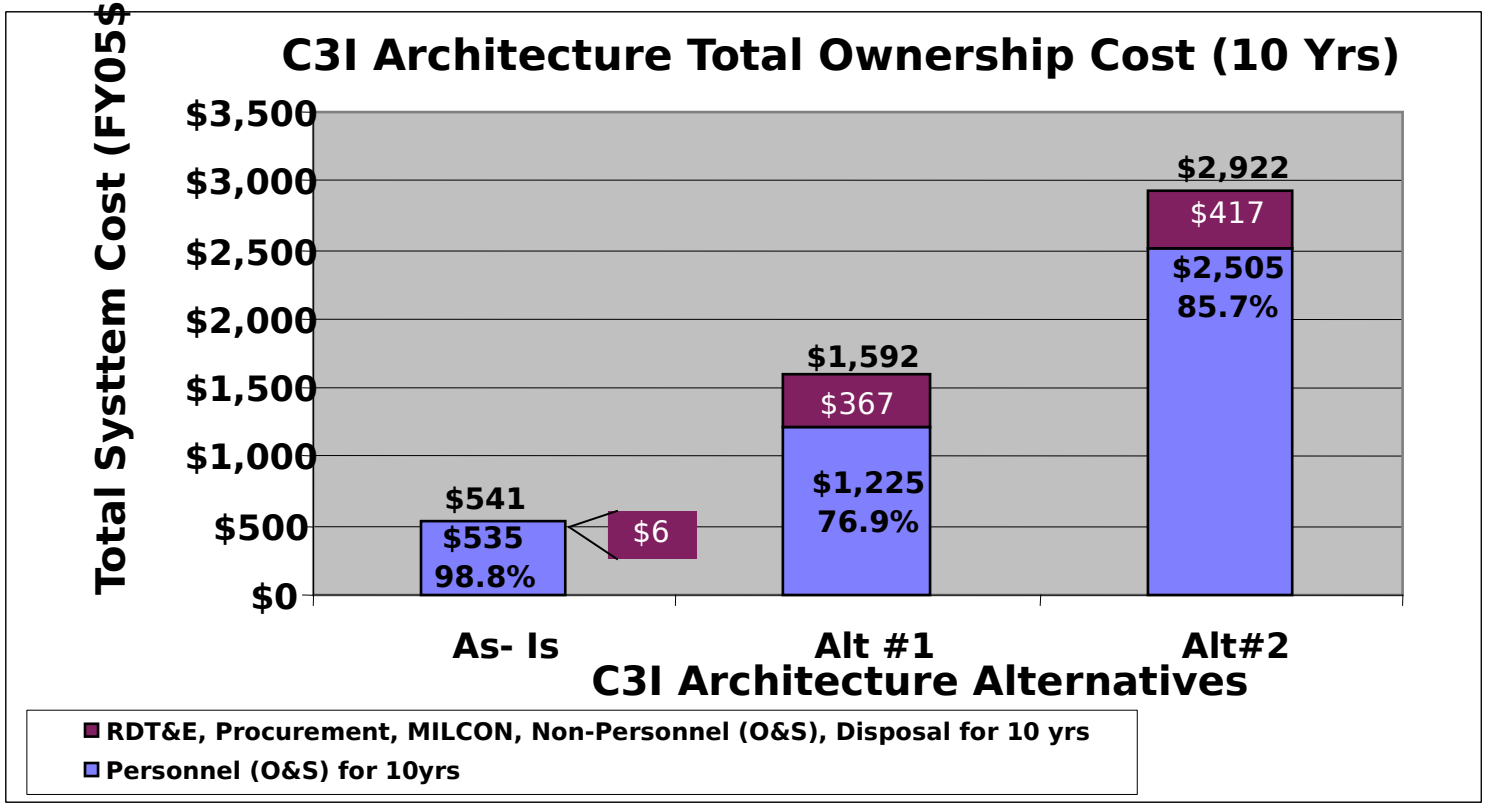


P (Decide Act | No Trigger Event);

- **P (Decide Engage | No Anomaly)**
- **P (Decide Inspect | No WMD)**

C3I Results Graphs

Staffing Cost Comparisons



Personnel Drives Cost

- **Accounts for most of Total C3I System Cost**

Insights and Recommendations

C3I Insights

- **Network Centric and Data Fusion Centers Drive C3I Improvements**
- **Network Centric C3I makes C2/Intel Center location irrelevant**
- **Decouple Analysis Time and Decision Quality to model C3I**
- **Humans still relevant in C3I process**
  - **Data Fusion**
  - **HUMINT**

RECOMMENDATIONS

- Invest Network Centric Communications System
- Invest in HUMINT
- Divide Region into “Data Fusion Cell” Regions.

C3I Group Questions ?

- SEA-7 Sensors
  - MAJ Russ Wyllie, USA
  - ENS Greg Woelfel, USN
  - ENS Alexis Wise, USN
  - Mr. David Rummler, Northrop-Grumman

- Communications Curriculum
  - MAJ Cheng Kiat Teo, RSN
  - Mr. Hong Siang Teo
  - Mr. Swee Jin Koh
  - Mr. Tat Lee Lim

- Information Assurance Curriculum
  - CPT Chay Chua, SinA
  - Mr. Chee Mun Ng
  - Mr. Nai Kwan Tan

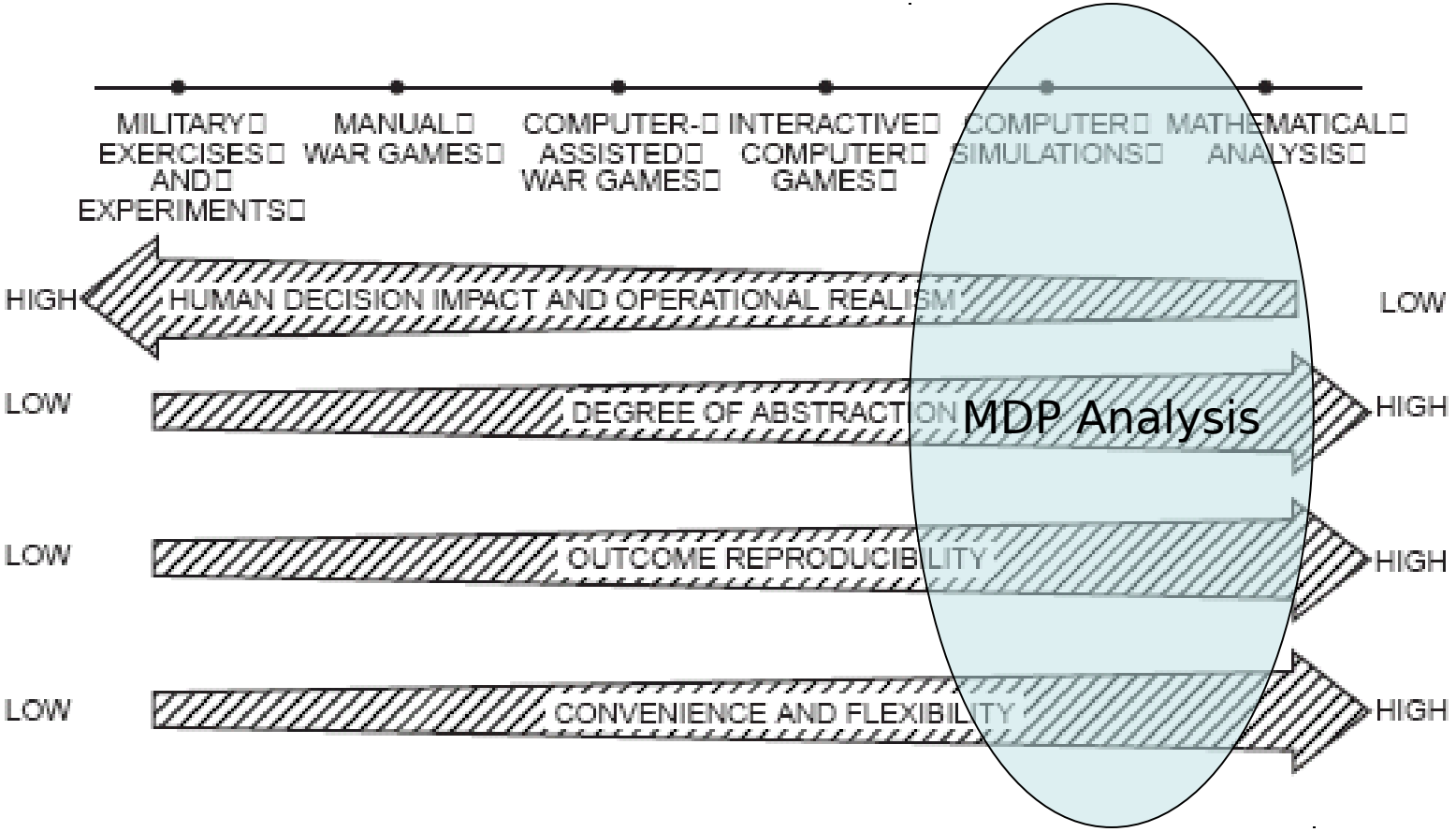
C3I Insights
Gaps

- Real time Common Operating Picture
- Consequence Assessment
- Anomaly Detection
- Modeling Human Behavior
  - Actions at various threat levels
  - Quality

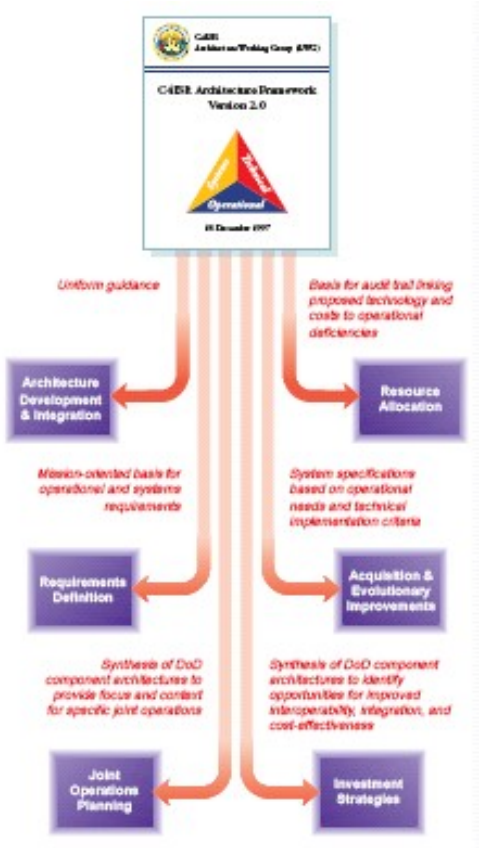
C3I Insights
Future Study

- Type II Decision (Quality) - [Tie False Alarm Rate to driving resources to $ to effectiveness]
- Test and evaluation of algorithms embedded in the data fusion are high risk to the ultimate performance of the overall MDP system.
- Complexity in the data fusion system engineering process is characterized:
  - representing the uncertainty in observations and in models of the phenomena that generate observations
  - combining non-commensurate information (e.g., the distinctive attributes in imagery, text, and signals)
  - maintaining and manipulating the enormous number of alternative ways of associating and interpreting large numbers of observations of multiple entities.
  - Staffing Ratio
- C3I Mod/Sim/Wargaming (Demonstration of Actual Human Behavior)
- Sensitivity/Cost Analysis various system component

Insight C3I Modeling (Human Reality)



Further C3I MDP Systems Design Required C4ISR Architecture Framework-Version 2.0 (1997)



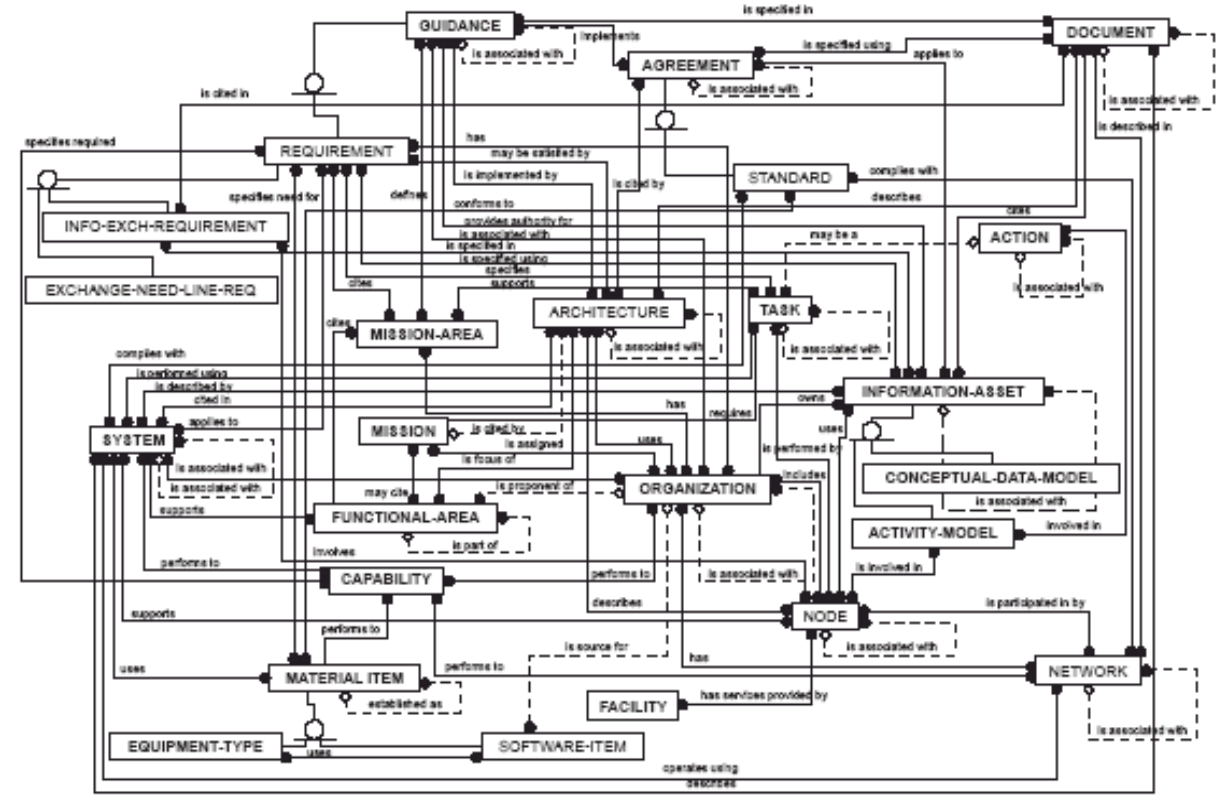


Figure 4-42. Overview of the Key Entities and Relationships for the C4ISR Core C4ISR Architecture Data Model (CADM)

Timeliness Model Inputs and Outputs

Inputs

- Track Quality: P_{track}
- Track Quality: P_{fa}
- Position Error: CEP mean
- Position Error: CEP variance
- Traffic Density
- RAM
- WMD Probability ($P_{present}$)
- Anomaly Probability (P_{occurs})
- Information Inputs:
  - External Intel (may be HUMINT, ELINT, or other types)
  - Internal Intel: Land Inspection information
  - Internal Intel: Sea Inspection information
  - Sensor Information

Outputs

- Time to make a decision (based on gathering any three pieces of information)

Goodness Model Inputs

- Probabilities
  - $P_{\text{Receive AIS information (Y/N)}}$
  - $P_{\text{AIS information is good}}$
  - $P_{\text{Receive external intelligence (Y/N)}}$
  - $P_{\text{External intelligence is good}}$
  - $P_{\text{Receive sea inspection information (Y/N)}}$
  - $P_{\text{Sea inspection information is good}}$
  - $P_{\text{Anomaly occur?}}$
  - $P_{\text{Inspection decision error}}$
  - $P_{\text{Pass decision error}}$

- Distribution Means and Standard Deviations*
  - AIS information arrival time μ and σ
  - Sea Inspection information arrival time μ and σ
  - External intelligence information arrival time μ and σ
  - Anomaly occurrence time μ and σ

*All information times are modeled by distributions based on scenario timelines